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AQUATIC ECOLOGY STUDIES

Yellowstone Fisheries Office Technical Report Number 1

FISHERIES INVENTORY AND INSTREAM FLOW REQUIREMENTS FOR REESE CREEK, YELLOWSTONE NATIONAL PARK

NATIONAL PARK SERVICE
WATER RESOURCES DIVISION
FORT COLLINS, COLORADO
RESOURCE ROOM PROPERTY

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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Fisheries Inventory and Instream Flow Requirements for Reese Creek, Yellowstone National Park

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Abstract

During 1984 and 1985, a fisheries inventory of Reese Creek, Yellowstone National Park, was conducted. Four fish species were captured in Reese Creek: cutthroat trout *Salmo clarki*, brown trout *Salmo trutta*, rainbow trout *Salmo gairdneri*, and mottled sculpin *Cottus bairderi*. Among these fish were migratory and stream resident populations.

Stream flow and the amount of water required to support fish populations utilizing Reese Creek was also documented during 1984 and 1985. Recommendations for maintaining instream water flows are included.

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Reese Creek is located along the northern boundary of Yellowstone National Park (YNP) about 4 miles northwest of the town of Gardiner. The stream originates above Cache Lake at an elevation of approximately 8200 ft and flows about 7 miles in a northeasterly direction before draining into the Yellowstone River (Figure 1). Reese Creek flows entirely across YNP lands and drains a basin of approximately 8400 acres. A total of five tributaries enter the stream.

Reese Creek is the only stream within YNP that has all of its water periodically removed for irrigation purposes. Three active irrigation diversions are located in the lower 1.5 miles of Reese Creek (Figures 1-4). The three privately owned active irrigation ditches divert water from the stream in a northerly direction. These ditches are located approximately 0.5, 0.9, and 1.2 miles upstream from the confluence with the Yellowstone River. The upper two ditches, either soley or in combination, are capable of diverting the entire flow of Reese Creek away from the main channel during periods of low stream flow.

Although water has been diverted from Reese Creek for about 100 years, the National Park Service has observed with concern that the severity of water depletions has increased in recent years. In response to this observation and initiation of a water rights adjudication process by the State of Montana, a study was established in 1984 to evaluate the aquatic resources of Reese Creek effected by water depletions. The objectives of this study were to 1) inventory the fishery resource of Reese Creek, 2) document the amount of water flowing in Reese Creek, and 3) determine quantities of stream flow necessary to sustain Reese Creek's fishery resource (establish a minimum stream flow requirement).

Methods

Fishery Inventory

To determine the presence of migratory or resident fish populations, Reese Creek was sampled by electrofishing three times in 1984 (21 May, 3 July, and 14 August) and once in 1985 (17 May). During 1984, the stream was sampled from the confluence upstream for approximately 2.0 miles including 0.25 mile sections of irrigation ditches #2 and #3. During 1985, only the lower 0.5 mile section below irrigation ditch #1 was sampled. Captured fish were identified to species, checked for gonad condition, and measured to the nearest 1 mm total length. Fish habitat parameters in the stream section affected by water diversions were measured on 4 July 1984. A macroinvertebrate sample was also collected on 4 July 1984.

Stream Flow

Stream flow in the main channel of Reese Creek was monitored with staff gauges. On 21 May 1984, two staff gauges were

REESE CREEK

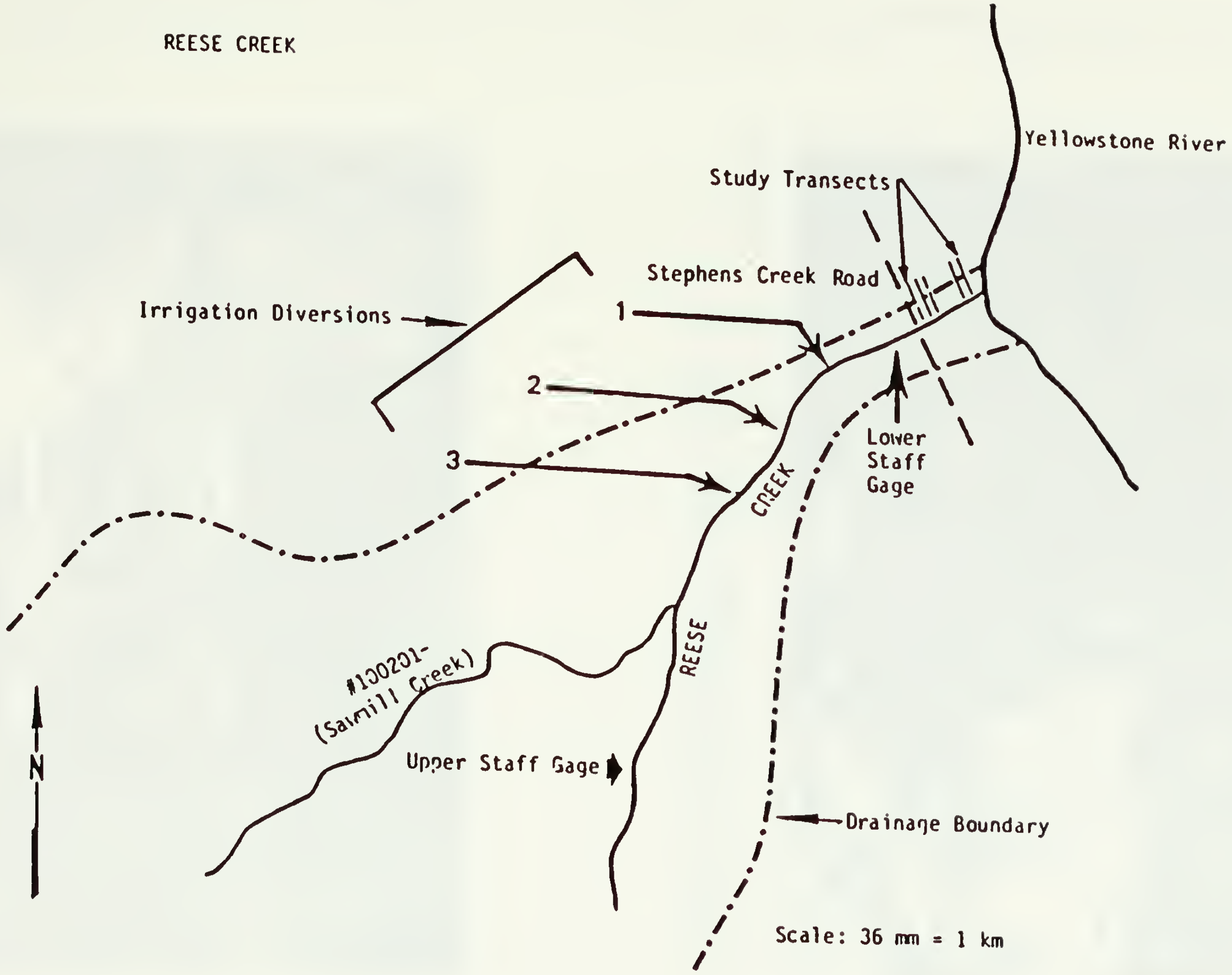

Figure 1. Hydrographic map of Reese Creek, Yellowstone National Park, indicating locations of irrigation diversions and study transects for determination of instream flow requirements.

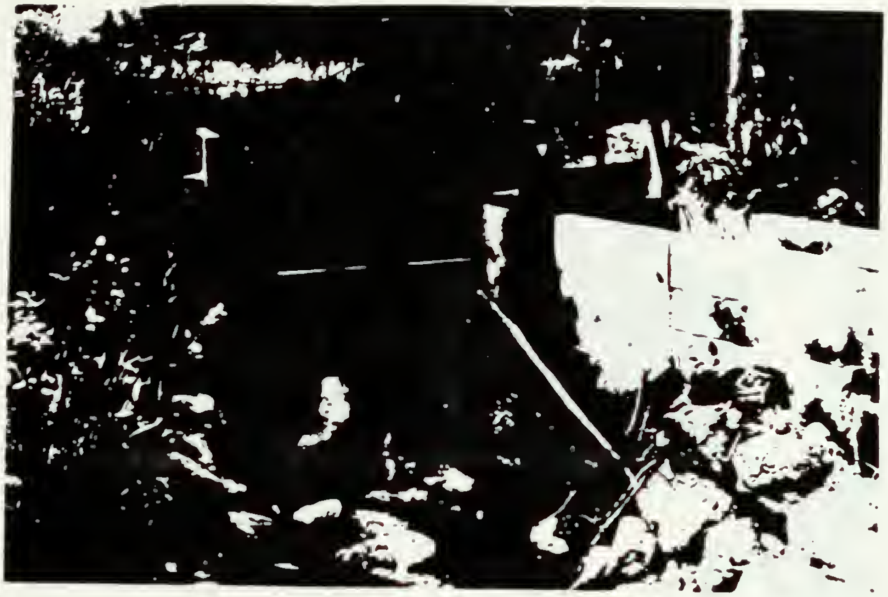

Figure 2. Headgate for irrigation diversion #1 located on Reese Creek, Yellowstone National Park.

Figure 3. Headgate for irrigation diversion #2 located on Reese Creek, Yellowstone National Park.

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Figure 4. Headgate for irrigation diversion #3 located on Reese Creek, Yellowstone National Park.

Figure 5. Study transect #5 used to determine the instream flow requirements for Reese Creek, Yellowstone National Park.

installed: one upstream and one downstream of all active diversions (Figure 1). The upper staff gauge was also upstream of stream #100201- (commonly referred to as Sawmill Creek). Staff gauges were calibrated to accurately measure discharge according to standard procedures outlined in Corbett (1962). Separate stage-discharge relationships were determined for the lower staff gauge during the 1984 and 1985 water years (Appendix Table 1), while the stage-discharge relationship for the upper staff gauge was based on measurements made during both years (Appendix Table 1). Water stage was generally recorded at least once each week from April to October (Appendix Tables 2-3). During 1985, however, water stage at the lower gauge was recorded once a day from 12 June through 30 September (Appendix Table 3). A relative measure of water flow in the irrigation ditches, based on visual estimates of the portion of ditch carrying water, was also noted weekly from April to October (Appendix Table 4). Discharge in Sawmill Creek was not measured; however, discharge estimates for this stream were derived from the two staff gauges during periods while no water was diverted.

Minimum Stream Flow Requirements

The wetted perimeter/inflection point method developed by the Montana Department of Fish, Wildlife and Parks (MDFWP) was used to derive a minimum flow necessary to support fish populations in Reese Creek. Standardized procedures outlined by Nelson (1984) were closely adhered to. Five riffle areas located in Reese Creek between Stephens Creek road and the Yellowstone River were selected as transect sites (Figures 1 and 5). Stream discharge and transect measurements were made on 19 April, 29 April, 21 June, and 15 October 1985. Fred Nelson, MDFWP, provided assistance and supervision in the collection of field data. This data was analyzed by the wetted perimeter program developed by MDFWP.

Results and Discussion

Stream Flow

Stream discharge averaged 8.8 cubic feet/second (cfs) at the upper staff gauge and 3.7 cfs at the lower staff gauge from 21 May through 19 November 1984 (Table 1, Appendix Table 2). The average amount of water diverted from Reese Creek for this period was at least 5.1 cfs each day or approximately 58% of the flow at the upper staff gauge. Because of the contribution of Sawmill Creek, this average value may have been as much as 0.7 cfs higher. During periods of no irrigation, Sawmill Creek contributed an average of 0.7 cfs of flow to Reese Creek with a range of 0.25-1.06 cfs (Appendix Tables 2-3). The largest amount of water diverted from Reese Creek in 1984 occurred on 21 May and totaled 10.7 cfs. The lower gauge site was dry on two consecutive weekly sample dates, suggesting that the main

Table 1. Mean discharge at staff gauges located above and below three irrigation diversions on Reese Creek, Yellowstone National Park, 1984-1985.

Year	Mean discharge (cfs)		Range of discharge (cfs)		Mean discharge (cfs) deficit between gauges
	Upper gauge	Lower gauge	Upper gauge	Lower gauge	
1984[1]	8.8 (n=22)	3.7 (n=23)	3.2-16.9	0.0-8.7	5.1
1985[2]	4.7 (n=34)	0.8 (n=123)	1.8-9.2	0.0-7.1	3.9

[1] Period of record was 21 May - 19 November: see Appendix Table 1.

[2] Period of record was 29 March - 12 October: see Appendix Table 2.

channel of Reese Creek was dry anywhere from 2 to 20 days in August (Figure 6, Appendix Tables 6 and 7)

From 29 March through 12 October 1985, mean discharge at the upper and lower staff gauges was 4.7 and 0.8 cfs, respectively (Table 1, Appendix Table 3). The average amount of water diverted from Reese Creek was at least 3.9 cfs each day or 83% of the flow at the upper staff gauge. The percentage of stream flow removal for irrigation increased by 25% from 1984 to 1985, but the amount of water removed decreased by 1.2 cfs. These values probably reflect the dry weather conditions that occurred during 1985. The largest amount of water diverted from Reese Creek in 1985 occurred on 24 May when all of the stream flow (9.2 cfs) was removed. The main channel of Reese Creek, below all diversions, was dry for a total of 96 days during the irrigation season, 86 of which were consecutive days (17 June-9 September) (Figure 6, Appendix Table 3). On several occassions, water flow at the upper gauge was over 7.8 cfs while no flow occurred at the lower gauge (Appendix Table 3).

During the two years that irrigation practices were recorded in the Reese Creek drainage, diversion #3 was the most active. Based on 42 observations, diversion #3 contained water 91% of the time, diversion #3 62% of the time, and diversion #1 52% of the time (Appendix Table 4). In many instances, diversions #2 and #3 removed all or most of the flow which left diversion #1 inactive.

Long-term mean annual flow for the main channel of Reese Creek, above the diversions, was estimated at 10.4 cfs by the United States Geological Survey (USGS) based on drainage basin characteristics, stream channel characteristics, average annual precipitation, and discharge estimates (C. Parrett, USGS Hydrologist, personal communication). Further, the USGS estimated total ditch capacity of the three diversions at 9.0 cfs. On five occassions during 1984 and 1985, the amount of water diverted from Reese Creek exceeded 9.0 cfs (Appendix Tables 2 and 3). The maximum amount diverted during this period was 10.7 cfs.

Fishery Inventory

Four fish species were captured in Reese Creek during 1984 and 1985: cutthroat trout *Salmo clarki*, brown trout *Salmo trutta*, rainbow trout *Salmo gairdneri*, and mottled sculpin *Cottus bairderi*. Among these fish were migratory and stream resident populations.

Resident population. Cutthroat trout was the only fish species that had a resident population in Reese Creek during 1984 and 1985. These fish were found throughout the stream channel with the largest numbers captured and observed above diversion #1 or more than 0.5 miles upstream from the confluence with the

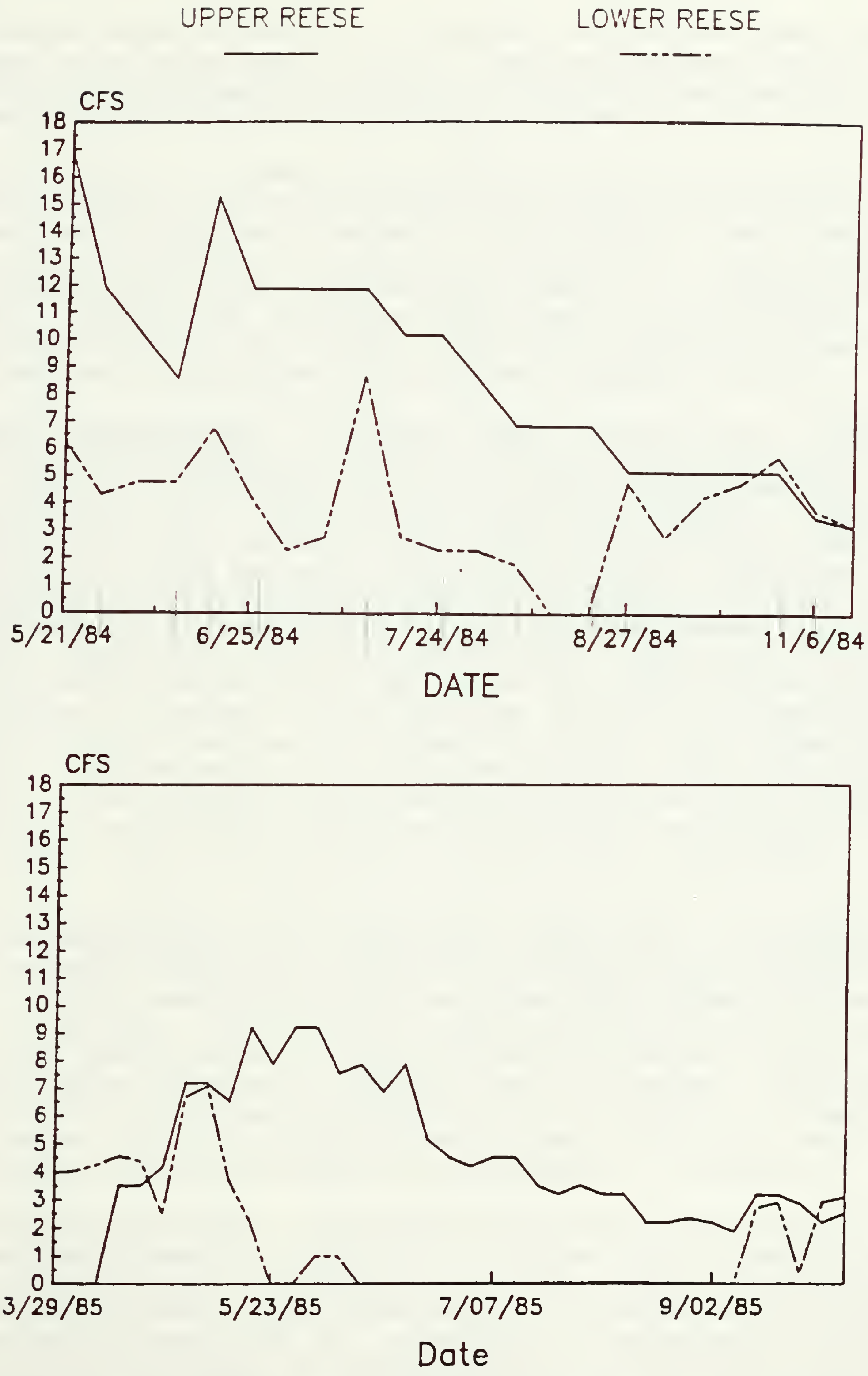

Figure 6. Stream flow pattern in Reese Creek, Yellowstone National Park, at the upper and lower staff guage sites, 1984 and 1985.

Yellowstone River (Table 2). Visually, these cutthroat trout appeared to be genetically pure. The road culvert and the irrigation diversions have probably served as barriers to upstream fish migration which have isolated this group of fish.

During periods of extremely low flow in the main channel, resident cutthroat trout between diversions were forced to migrate into irrigation ditches. On 14 August 1984, the main channel below diversion #1 was dry (Figure 7). Irrigation ditch #3 contained more flow than the main channel of Reese Creek below it. One or two cutthroat trout were seen in this irrigation ditch at that time. These fish probably entered the ditch because it contained the greatest amount of flow.

Migratory populations. Cutthroat trout, brown trout, rainbow trout, and mottled scuplin are belived to migrate into Reese Creek from the Yellowstone River for spawning or feeding purposes (Table 2). The distance these fish migrate upstream is limited by the road culvert (Figure 8) and irrigation diversions (Figures 2-4) which serve as periodic barriers. Physical characteristics of the stream channel, downstream of diversion #1, indicated this section of stream provided substrate suitable for trout spawning, well developed pools, substantial vegetation overhang, and instream cover suitable for trout (Appendix Table 5). Further, a total of five species of macroinvertebrates were captured in this section of stream on 3 July 1984 (Appendix Table 6). The majority of macroinvertebrates captured were mayflies. This sample was representative of macroinvertebrate communities occurring in streams in Yellowstone National Park that support trout populations (Jones et al. 1984-1986).

Substantial evidence indicates brown trout from the Yellowstone River use Reese Creek as a spawning tributary. No sexually mature or adult fish were captured in Reese Creek, however, the stream was not sampled during the brown trout spawning period. Young of the year (YOY) brown trout were found in the stream during the spring of both years (Table 2). Brown trout generally spawn between 15 October and 1 December, and eggs incubate into early spring (Raleigh et al. 1984). In Reese Creek, water flows are usually maintained from early fall through early spring because of cessation of irrigation.

Rainbow trout from the Yellowstone River were captured in Reese Creek on two occassions (Table 2). These fish ranged in length from 6.3 to 8.3 in. Although Reese Creek contains suitable habitat for rainbow trout spawning, no evidence was collected that suggests these fish are successfully reproducing in this stream. Further study is needed before a definitive conclusion can be drawn as to the contribution of Reese Creek to the Yellowstone River rainbow trout population.

Mottled sculpin were sampled on one occasion (Table 2). These fish probably entered Reese Creek to feed on the large amount of

Table 2. List, including length and number of resident and migratory populations of fish captured in Reese Creek, Yellowstone National Park, 1984-1985.

Species	Date	Distance above confluence (miles)	Number	Length (inches)
Cutthroat trout	21 May 1984	0.5-1.2	2	6.9-8.9
	21 May 1984	1.2-2.0	2	4.4-7.1
	14 August 1984	irrigation ditch	1-2	---
Rainbow x cutthroat	21 May 1984	0.0-0.5	2	4.0-9.1
Rainbow trout	3 July 1984	0.0-0.5	1	8.3
	17 May 1985	0.0-0.5	2	6.3-6.6
Brown trout	3 July 1984	0.0-0.5	1	2.4
	17 May 1985	0.0-0.5	5	1.8-2.5
Mottled sculpin	3 July 1984	0.0-0.5	2	2.5-3.3

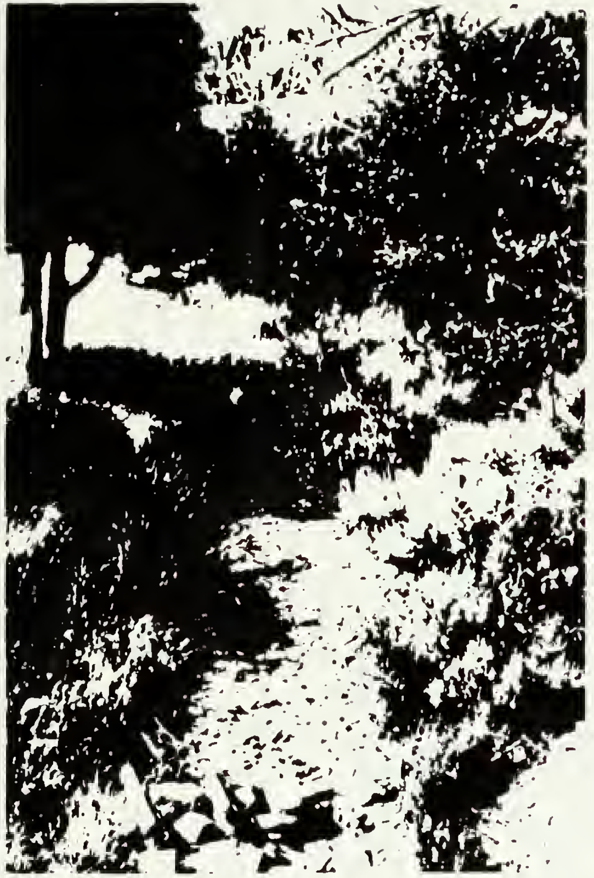

Figure 7. Section of Reese Creek, Yellowstone National Park, between the Yellowstone River confluence and irrigation diversion #1 on 14 August 1984.

Figure 8. Road culvert located on Reese Creek, Yellowstone National Park.

insect drift in the stream at that time. No evidence suggests that mottled sculpin spawn in Reese Creek.

The most significant fishery value of Reese Creek is its provision of spawning habitat for Yellowstone cutthroat trout S. c. bouvieri inhabiting the Yellowstone River. This fish is listed as a species of special concern by MDFWP and pure populations in Montana inhabit only 8% of their original range (Hadley 1984). Concern for the status of the Yellowstone cutthroat in Montana has been present for many years. In 1975, Berg stated:

> "Because of the present limited distribution and abundance, especially of pure strain of Yellowstone cutthroat, every effort should be made for perpetuation and improvement of the remaining populations of these cutthroat".

On 1 May 1984, catch and release regulations for cutthroat trout were imposed on the Yellowstone River from YNP boundary to Pine Creek Bridge. This regulation was initiated to prevent the further decline of this valuable population (Clancy 1985). Implementation of the regulation resulted from a significant lack of older, larger, reproducing individuals in the population. Clancy (1984) found that this cutthroat trout population was the most stable in sections of the Yellowstone River that had tributaries where cutthroat trout were successfully reproducing. Furthermore, cutthroat trout travel distances up to 31 miles to spawn in tributaries with a high percentage of reproductive habitat (Berg 1975; Clancy 1984, 1985; Javorsky 1984). Berg (1975) indicated that one of the major elements responsible for the overall decline of cutthroat trout in the Yellowstone River was the complete diversion of major tributaries for irrigation immediately after spawning.

Only three tributaries to the Yellowstone River between the YNP boundary and Yankee Jim Canyon have been documented to have spawning runs of cutthroat trout (Berg 1975; Clancy 1984, 1985; Javorsky 1984; Oswald 1982). These streams are Bear Creek, Cedar Creek, and Mol Heron Creek (Figure 9). Generally, cutthroat trout spawn in these streams between the first week in June and the first week in August with the peak of the migration occurring in mid-July (Berg 1975; Clancy, 1984, 1985; Javorsky 1984; Oswald 1982). The size of these spawning fish ranged from 9.4 in to 18.1 in. Berg (1975) indicated that eggs incubate from 4.5 to 6 weeks after spawning or into mid-September for late spawners.

Two sexually mature male trout were captured in Reese Creek on 21 May 1984. One of these fish was identified as a pure Yellowstone cutthroat trout and captured between diversion #1 and Stephens Creek road. The other was identified as a possible hybrid between rainbow and cutthroat trout and captured immediately downstream of the road culvert. Based on their

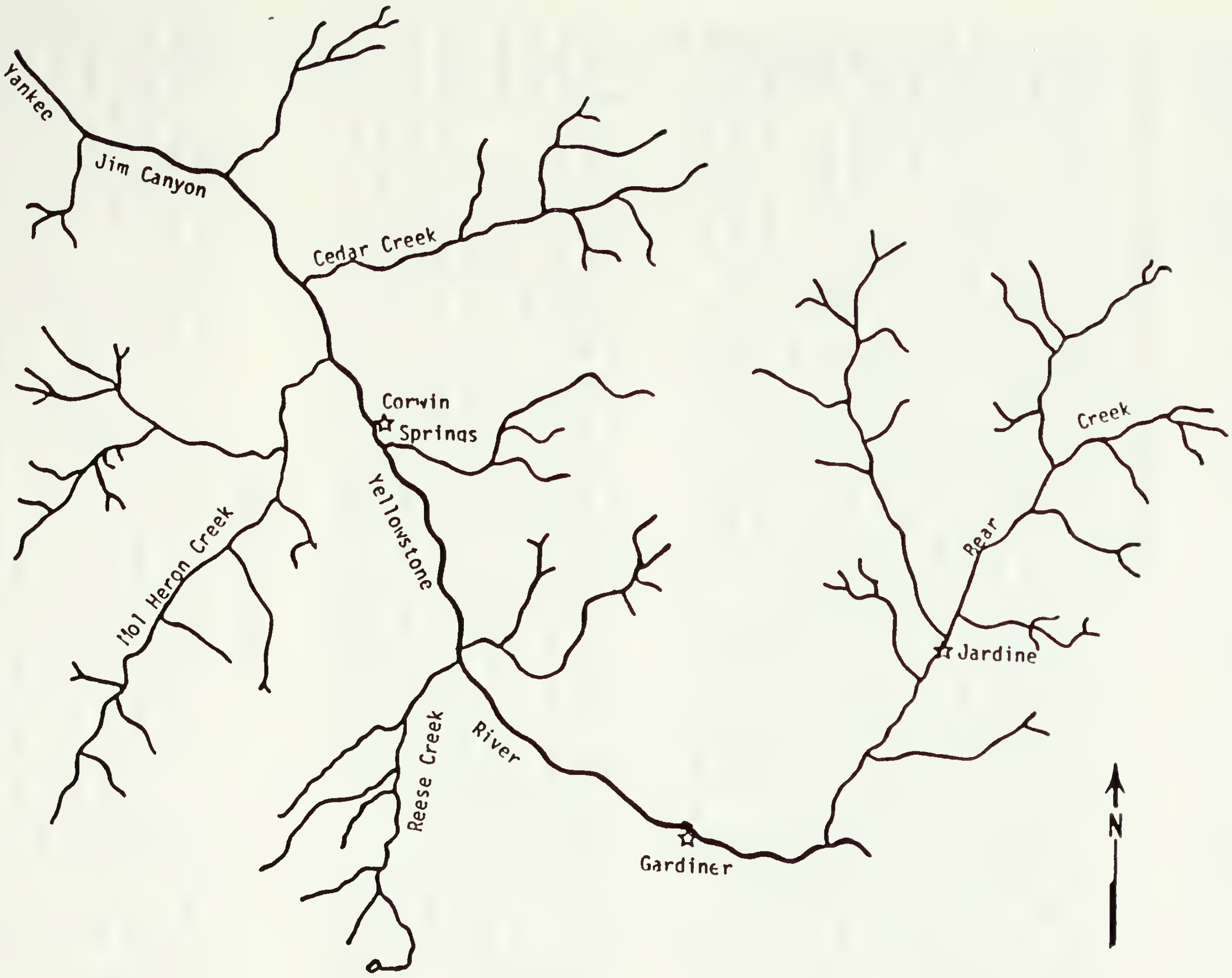

Figure 9. Locations of tributaries to the Yellowstone River, between Yankee Jim Canyon and the Northern boundary of Yellowstone National Park, used by cutthroat trout for spawning.

location of capture, we feel these fish migrated from the Yellowstone River into Reese Creek to spawn. Further, they are probably the remnants of a once substantial run of cutthroat trout that spawned in Reese Creek and has been diminished due to historic irrigation practices. If cutthroat trout spawned in the lower section of Reese Creek during 1984 or 1985, their reproductive success was nil because of the dewatering of the stream channel.

Minimum Stream Flow Requirements

The amount of water flow required to sustain fish populations in Reese Creek was based on two techniques outlined by Nelson (1984). The first technique estimated the amount of water required to consistently produce abundant, healthy, and thriving aquatic populations. This flow was based on the wetted perimeter-flow relationship determined from five transect locations along the stream channel. A range of flows necessary to sustain fish populations was selected based on the value of the fishery in question and determined by inflection points of a line representing the relationship (Figure 10, Appendix Table 7). For Reese Creek, the upper inflection point was selected because it contained Yellowstone cutthroat trout, a fish species of special concern. The amount of water required in Reese Creek during low flow periods, therefore, was estimated at 1.6 cfs.

The second technique for estimating the minimum flow requirement for Reese Creek was based on the passage of migratory trout. In Reese Creek, sufficient stream flows are needed not only for spawning, rearing, and feeding habitats, but also to provide enough flow while adult trout migrate upstream to spawning areas. A minimum passage flow was estimated based on the assumption that at least 25% of the top width of each cross-section should have water depth greater than or equal to the minimum needed for fish passage (0.4 ft). In Reese Creek, the flow that satisfied these criteria was 4.3 cfs (Appendix Table 8).

Conclusions

Reese Creek supports a varied community of fish species. The lower section of stream provides substantial areas that are suitable for spawning by Yellowstone River brown, cutthroat, and rainbow trout. Brown trout reproduce successfully in Reese Creek because stream flows are maintained during the fall, winter, and spring. Yellowstone River cutthroat trout are not successfully reproducing in Reese Creek because water flows are not maintained in the lower section of the stream and fish barriers (road culvert and diversions) prevent their upstream migration into areas where flows are maintained.

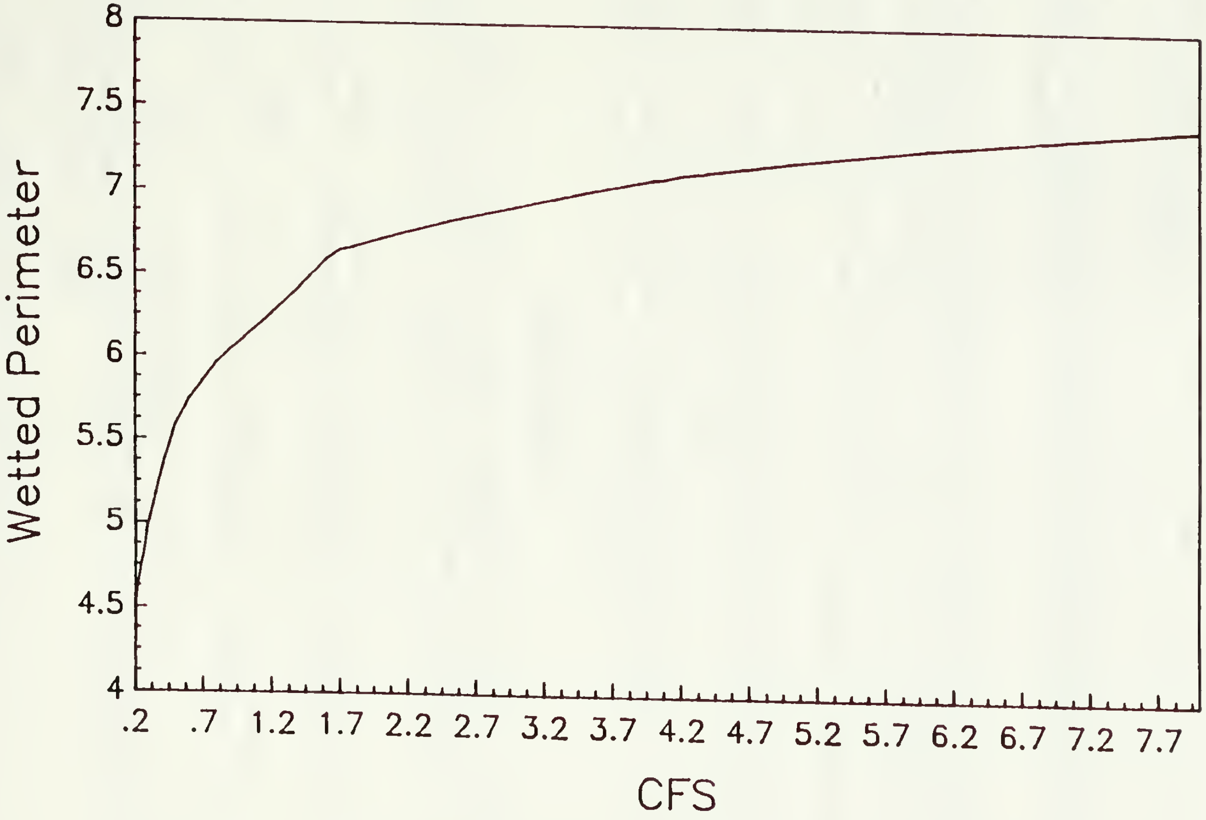

Figure 10. Relationship between stream flow and wetted perimeter for Reese Creek, Yellowstone National Park.

Recommendations

The objectives of the fishery management program in Yellowstone National Park are to:

1. Manage fish populations as integral parts of the park's ecosystem.
2. To preserve and restore native species and aquatic habitat.

To meet these objectives for Reese Creek, the following recommendations are made:

1. Maintain instream flow of 4.3 cfs from 15 May to 30 July for spawning cutthroat trout migrating from Yellowstone River.

2. Maintain instream flow of 4.3 cfs from 1 October to 1 December for spawning brown trout migrating from Yellowstone River.

3. Maintain instream flow of 1.6 cfs for the remaining time period.

4. Alter road culvert and irrigation diversions to allow upstream migration of fish.

5. Place grates across irrigation diversions to prevent fish from migrating into ditches.

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Appendix Table 1. Stage-discharge relationships determined for staff gauges installed on the main channel of Reese Creek, Yellowstone National Park, 1984-1985.

Staff gauge	Year	Stage-discharge relationship	Sample Size	r	t value
Above diversions	1984-1985	Discharge (cfs)=33.56 (staff height)-347.09	18	0.96	13.38
Below diversions	1984	Discharge (cfs)=9.90 (staff height)-78.42	10	0.91	6.46
	1985	Discharge (cfs)=10.54 (staff height)-108.17	6	0.89	3.97

Appendix Table 2. Stream flow patterns at the upper and lower staff gauges located on Reese Creek, Yellowstone National Park, 1984.

	Upper Staff Gauge		Lower Staff Gauge		
Date	Staff Height	Discharge (cfs)	Staff Height	Discharge (cfs)	Minimum amount of water diverted (cfs)
05/21/84	10.85	16.94	8.55	6.25	10.69
05/29/84	10.70	11.90	8.35	4.27	7.64
06/05/84	10.65	10.23	8.40	4.76	5.47
06/11/84	10.60	8.55	8.40	4.76	3.79
06/18/84	10.80	15.26	8.60	6.74	8.52
06/25/84	10.70	11.90	8.35	4.27	7.64
07/03/84	10.70	11.90	8.15	2.29	9.62
07/04/84			8.14	2.29	
07/06/84	10.70	11.90	8.20	2.78	9.12
07/10/84	10.70	11.90	8.80	8.72	3.18
07/16/84	10.65	10.23	8.20	2.78	7.45
07/24/84	10.65	10.23	8.15	2.29	7.94
07/30/84	10.60	8.55	8.15	2.29	6.26
08/07/84	10.55	6.87	8.10	1.79	5.08
08/13/84	10.55	6.87	0.00	0.00	6.87
08/20/84	10.55	6.87	0.00	0.00	6.87
08/27/84	10.50	5.19	8.40	4.76	0.43
09/04/84	10.50	5.19	8.20	2.78	2.41
09/10/84	10.50	5.19	8.35	4.27	0.93
09/17/84	10.50	5.19	8.40	4.76	0.43
09/24/84	10.50	5.19	8.50	5.75	
11/06/84	10.45	3.52	8.30	3.77	
11/19/84	10.44	3.18	8.24	3.18	0.00
Average	10.61	8.76	7.61	3.71	
Maximum	10.85	16.94	8.80	8.72	
Minimum	10.44	3.18	0.00	0.00	

Appendix Table 3. Stream flow patterns at the upper and lower staff gauges located on Reese Creek, Yellowstone National Park, 1985.

	Upper Staff Gauge		Lower Staff Gauge		Maximum amount of water diverted (cfs)
Date	Staff Height	Discharge (cfs)	Staff Height	Discharge (cfs)	
03/29/85			10.64	3.95	
04/04/85			10.65	4.05	
04/11/85			10.67	4.26	
04/15/85	10.45	3.52	10.70	4.58	
04/18/85			10.74	5.00	
04/22/85	10.45	3.52	10.68	4.37	
04/26/85			10.72	4.79	
04/30/85	10.47	4.19	10.50	2.47	1.72
05/06/85	10.56	7.21	10.90	6.69	0.52
05/10/85			10.68	4.37	
05/12/85	10.56	7.21	10.94	7.11	0.10
05/14/85			10.62	3.73	
05/17/85	10.54	6.53	10.62	3.73	2.80
05/22/85	10.62	9.22	10.48	2.26	6.96
05/23/85	10.58	7.88	10.18	0.00	7.88
05/24/85	10.62	9.22	10.24	0.00	9.22
05/30/85			10.44	1.84	
06/03/85	10.62	9.22	10.36	1.00	8.22
06/06/85			10.57	3.21	
06/11/85	10.57	7.54	10.36	1.00	6.55
06/12/85	10.58	7.88	10.16	0.00	7.88
06/13/86			10.16	0.00	
06/14/86			10.16	0.00	
06/15/85			10.50	2.47	
06/16/85			10.46	2.05	
06/17/85			10.16	0.00	
06/18/85			10.16	0.00	
06/19/85			10.16	0.00	
06/20/85	10.55	6.87	10.16	0.00	6.87
06/21/85	10.58	7.88	10.16	0.00	7.88
06/22/85			10.16	0.00	
06/23/85			10.16	0.00	
06/24/85			10.16	0.00	
06/25/85			10.16	0.00	
06/26/85			10.16	0.00	
06/27/85			10.16	0.00	
06/28/85	10.50	5.19	10.16	0.00	5.19
06/29/85	10.48	4.52	10.16	0.00	4.52
06/30/85			10.16	0.00	
07/01/85			10.16	0.00	
07/02/85			10.16	0.00	
07/03/85			10.16	0.00	

Appendix Table 3. continued.

Date	Upper Staff Gauge		Lower Staff Gauge		Maximum amount of water diverted (cfs)
	Staff Height	Discharge (cfs)	Staff Height	Discharge (cfs)	
07/04/85			10.16	0.00	
07/05/85			10.16	0.00	
07/06/85	10.47	4.19	10.16	0.00	4.19
07/07/85	10.48	4.52	10.16	0.00	4.52
07/08/85			10.16	0.00	
07/09/85			10.16	0.00	
07/10/85			10.16	0.00	
07/11/85			10.16	0.00	
07/12/85			10.16	0.00	
07/13/85	10.48	4.52	10.16	0.00	4.52
07/14/85			10.16	0.00	
07/15/85			10.16	0.00	
07/16/85			10.16	0.00	
07/17/85			10.16	0.00	
07/18/85			10.16	0.00	
07/19/85					
07/20/85	10.45	3.52	10.16	0.00	3.52
07/21/85			10.16	0.00	
07/22/85					
07/23/85					
07/24/85			10.16	0.00	
07/25/85			10.16	0.00	
07/26/85			10.16	0.00	
07/27/85	10.44	3.18	10.16	0.00	3.18
07/28/85			10.16	0.00	
07/29/85			10.16	0.00	
07/30/85			10.16	0.00	
07/31/85			10.16	0.00	
08/01/85			10.16	0.00	
08/02/85					
08/03/85			10.16	0.00	
08/04/85	10.45	3.52	10.16	0.00	3.52
08/05/85			10.16	0.00	
08/06/85			10.16	0.00	
08/07/85			10.16	0.00	
08/08/85			10.16	0.00	
08/09/85	10.44	3.18	10.16	0.00	3.18
08/10/85	10.44	3.18	10.16	0.00	3.18
08/11/85					
08/12/85			10.16	0.00	
08/13/85			10.16	0.00	
08/14/85			10.16	0.00	
08/15/85					
08/16/85					

Appendix Table 3. continued.

Date	Upper Staff Gauge Staff Height	 Discharge (cfs)	Lower Staff Gauge Staff Height	 Discharge (cfs)	Maximum amount of water diverted (cfs)
08/17/85			10.16	0.00	
08/18/85	10.41	2.17	10.16	0.00	2.17
08/19/85			10.16	0.00	
08/20/85			10.16	0.00	
08/21/85			10.16	0.00	
08/22/85					
08/23/85					
08/24/85			10.16	0.00	
08/25/85	10.41	2.17	10.16	0.00	2.17
08/26/85			10.16	0.00	
08/27/85			10.16	0.00	
08/28/85			10.16	0.00	
08/29/85			10.16	0.00	
08/30/85					
08/31/85			10.16	0.00	
09/01/85	10.42	2.34	10.16	0.00	2.34
09/02/85	10.41	2.17	10.16	0.00	2.17
09/03/85			10.16	0.00	
09/04/85					
09/05/85			10.16	0.00	
09/06/85			10.16	0.00	
09/07/85			10.16	0.00	
09/08/85	10.40	1.84	10.16	0.00	1.84
09/09/85			10.16	0.00	
09/10/85			10.36	1.00	
09/11/85			10.16	0.00	
09/12/85			10.26	0.00	
09/13/85			10.16	0.00	
09/14/85					
09/15/85			10.16	0.00	
09/16/85			10.16	0.00	
09/17/85			10.26	0.15	
09/18/85			10.28	0.15	
09/19/85			10.48	2.26	
09/20/85			10.50	2.47	
09/21/85	10.44	3.18	10.52	2.68	0.50
09/22/85	10.44	3.18	10.54	2.89	0.29
09/23/85			10.35	0.89	
09/24/85			10.34	0.78	
09/25/85	10.43	2.84	10.30	0.36	2.48
09/26/85			10.30	0.36	
09/27/85			10.40	1.42	
09/28/85			10.54	2.89	
09/29/85			10.54	2.89	

Appendix Table 3. continued.

Date	Upper Staff Gauge		Lower Staff Gauge		Maximum amount of water diverted (cfs)
	Staff Height	Discharge (cfs)	Staff Height	Discharge (cfs)	
09/30/85			10.50	2.47	
10/02/85	10.41	2.17	10.54	2.69	
10/12/85	10.42	2.51	10.56	3.10	
Average	10.49	4.76	10.27	0.84	
Maximum	10.62	9.22	10.94	7.11	
Minimum	10.40	1.84	10.16	0.00	
Sample Size	34.00		122.00		

Appendix Table 4. Use of irrigation diversions on Reese Creek, Yellowstone National Park, 1984-1985.

	Flow in Ditches		
Date	Diversion #1	Diversion #2	Diversion #3
05/29/84	Full	Full	Full
06/11/84	Full	Full	Full
06/18/84	Dry	1/8 Full	Full
06/25/84	Dry	1/2 Full	Full
07/03/84	1/2 Full	Full	Full
07/06/84	1/2 Full	Full	Full
07/10/84	Full	Dry	Full
07/16/84	3/4 Full	Dry	Full
07/24/84	1/16 Full	Full	Full
07/30/84	1/16/Full	Full	Full
08/07/84	1/16 Full	Full	Full
08/13/84	1/2 Full	Full	Full
08/20/84	1/3 Full	Full	Full
09/04/84	Full	1/2 Full	1/2 Full
09/10/84	Full	Dry	1/2 Full
09/17/84	1/2 Full	Dry	1/2 Full
09/24/84	1/2 Full	Dry	1/2 Full
11/06/84	Dry	Dry	1/8 Full
01/03 85	Dry	Dry	Dry
04/15/85	Dry	Dry	Dry
04/22/85	Dry	Dry	Dry
04/30/85	Dry	Dry	Full
05/06/85	Dry	Dry	1/2 Full
05/12/85	Dry	Dry	Dry
05/23/85	Full	Full	Full
06/11/85	1/2 Full	Full	Full
06/20/85	1/4 Full	1/4 Full	3/4 Full
06/29/85	1/16 Full	3/4 Full	Full
07/06/85	1/16 Full	3/5 Full	7/8 Full
07/13/85	Dry	3/4 Full	7/8 Full
07/20/85	Dry	3/4 Full	3/4 Full
07/27/85	1/4 Full	3/5 Full	7/8 Full
08/04/85	Dry	4/5 Full	7/8 Full
08/10/85	Dry	4/5 Full	7/8 Full
08/18/85	Dry	Full	3/4 Full
08/25/85	Dry	7/8 Full	Full
09/02/85	Dry	7/8 Full	7/8 Full
09/08/85	1/4 Full	3/5 Full	Full
09/21/85	Dry	Dry	5/8 Full
09/25/85	Dry	Dry	Full
10/02/85	Dry	Dry	3/4 Full
10/12/85	Dry	Dry	5/8 Full
Percentage of time used	52	62	91

Appendix Table 5. Habitat features of the main channel of Reese Creek, Yellowstone National Park, approximately 0.5 miles upstream from the confluence with the Yellowstone River, 4 July 1984.

Habitat Features:	Transect			Average
	#1	#2	#3	
Water Column:				
Channel Width (ft)	9.5	11.0	13.5	11.3
Stream Width (ft)	5.2	11.0	6.0	7.4
Stream Depth (ft)	0.5	0.8	0.5	0.6
Stream Shore Water Depth (ft)	0.0	0.1	0.0	0.0
Riffle Width (ft)	5.2	4.8	6.0	5.3
Pools:				
Width (ft)	0.0	5.8	0.0	1.9
Quality	---	2.0	---	---
Feature	---	1.0	---	---
Solar Incidence	60.0	80.0	75.0	71.7
Channel Morphology:				
Streambank Alteration	62.0	10.0	80.0	50.7
Vegetative Stability	2.0	4.0	1.0	2.3
Undercut (ft)	0.0	0.0	0.0	0.0
Channel-Bank Angle	140.0	132.5	132.5	135.0
Stream Bottom:				
Gradient	3.0	5.6	3.0	3.9
Sinuosity	1.3	1.1	1.0	1.1
Substrate (ft)				
Boulder > 256 mm	0.0	0.0	0.0	0.0
Cobble 64-256 mm	3.0	2.0	3.0	2.7
Gravel 2-64 mm	1.0	6.0	1.0	2.7
Sand 0.6-2 mm	0.0	0.0	1.0	0.3
Silt < 0.6 mm^	1.0	1.0	0.0	0.7
Embeddedness	5.0	3.0	4.0	4.0
Channel Vegetative Cover (ft)	2.0	0.5	1.1	1.2
Riparian Zone:				
Streamside Cover	3.0	4.0	1.0	2.7
Vegetative Use	0.0	0.0	0.0	0.0
Vegetation Overhang (ft)	0.8	4.0	1.0	1.9
Habitat Type	13.0	20.0	17.0	---

Appendix Table 6. Occurrence and densities of macroinvertebrates found in Reese Creek, Yellowstone National Park, 1984.

	Density (number)
Arthropoda	
Insecta	
Ephemeroptera (mayflies)	
Baetidae	
Baetis bicaudatus	15
Ephmerellidae	
Drunella coloradensis	1
Drunella doddsi	2
Heptageniidae	
Epeorus grandis	1
Trichoptera (caddisflies)	
Limnephildae	
Neothremma sp.	1
TOTAL NUMBER OF SPECIES	5

Appendix Table 7. Relationship between stream flow and wetted perimeter for Reese Creek, Yellowstone National Park.

Flow	Wetted Perimeter
0.2	4.52
0.3	5.00
0.4	5.33
0.5	5.59
0.6	5.74
0.7	5.85
0.8	5.96
0.9	6.04
1.0	6.11
1.2	6.26
1.4	6.42
1.6	6.59
1.7	6.65
1.8	6.67
2.0	6.72
2.5	6.83
3.0	6.92
3.5	7.01
4.0	7.09
4.1	7.10
4.2	7.12
4.3	7.13
4.4	7.14
4.5	7.15
5.0	7.20
6.0	7.29
7.0	7.36
8.0	7.43

Appendix Table 8. Relationship between stream flow and the percentage of cross-section width greater than 0.4 ft deep in Reese Creek, Yellowstone National Park.

	Percentage of cross-section width greater than 0.4 ft deep				
	Transect #				
Flow (cfs)	1	2	3	4	5
1.0	0.0	0.0	12.1	12.4	46.2
2.0	0.0	6.9	15.8	25.6	52.4
3.0	15.1	16.9	9.6	29.2	55.0
4.0	21.3	41.2	23.2	39.7	56.9
4.3	25.4	42.3	25.3	41.0	57.4
5.0	42.6	44.6	30.6	47.3	60.7
6.0	50.8	52.7	36.7	60.6	68.5

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